IMPLICATIONS OF AGE APPROPRIATE ATTAINMENT OF EARLY MOTOR SKILLS ON FINE AND GROSS MOTOR SKILLS IN FOUR AND FIVE YEAR OLD CHILDREN

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Abstract

Objective: The aim of this study is to discover the possible implications of early gross motor skills such as rolling, crawling, creeping, and scooting on the later fine and gross motor development of four and five year olds.

Methods: A description of the research study, a consent form, and a retrospective parent questionnaire regarding early milestones were distributed to the parents and/or guardians of all four and five year old children enrolled in the San Angelo Early Childhood Center. Twenty-seven participants were included in data collection. After forms were returned, the Peabody Developmental Motor Scales - 2 was then administered to assess each participant's gross and fine motor skills.

Results: No statistically significant differences were found when comparing early gross motor skill achievement – rolling stomach to back, rolling back to stomach, crawling, creeping, and scooting - and later PDMS-2 *gross* motor quotients. Similarly, no statistically significant differences were found comparing rolling stomach to back, rolling back to stomach, crawling, and scooting achievement and later *fine* motor quotients. However, when comparing the achievement of creeping and later fine gross motor quotients, a statistically significant difference was found between groups of early, average, and late attainment. Despite only one of our comparisons being statistically significant, there were multiple between groups comparisons displaying a negative correlation between early motor skill achievement and motor quotients.

Discussion: The importance of achieving early milestones generally occurring before the age of one is debated among healthcare professionals and research worldwide. Although statistical analysis did not reveal significant differences between groups of early, average, and late attainment of early milestones such as rolling, crawling, creeping, and scooting compared to later motor skills, our study did demonstrate expected negative correlation between the variables for most skills.

Keywords: *motor milestone, gross motor skill, fine motor skill, Peabody Developmental Motor Scales -2, crawling, creeping, rolling, scooting*

Introduction

The normal development of fine and gross motor skills of children is a common subject of interest for many parents, healthcare professionals, and researchers. When working with children in the medical and therapeutic fields, it is essential to have an understanding of normal development patterns and age appropriate motor skills to identify if development is normal or impaired.

The study of children's motor development began more than 100 years ago with a focus on the typical child. Early researchers in child development, including Gesell, established a list of motor skills that were expected to be achieved for each month of life and a detailed, normative sequence of motor skill development[1,2]. Normative ages at which children were expected to acquire new motor skills were based on group averages of the age of skill acquisition[1]. Early research in motor development suggested that skills or milestones occurred in a specific, fixed sequence in which skills could not be skipped, occur out of order, or occur concurrently[1]. However, more recent research has shown that there is variation in motor development. A child's development is expected to follow a generalized sequence, but does not have to adhere to a strict sequence and time line. A research study by Karen Adolph and colleagues found that most infants completed skills that were within multiple stages of development simultaneously[2].

Variation in motor skill development has also been noted across cultures. For example, a study by Geber showed advanced motor skills in infants in Uganda with infants that began walking at 10 months and running at 14 months as compared to American infants who began walking at 11.7 to 12.5 months and running at 18 months[1]. It is important to note that the only

skills that were accelerated were the skills emphasized within the cultural context, regardless of ethnicity[1]. Formal training to promote motor skills and informal handling practices of infants are cultural influences that affect the age of skill acquisition as the result of various amounts of stimulation and opportunities to practice skills in positions such as prone or upright[1].

In addition, some infants may even skip the development of specific motor skills often including crawling. Skipping the development of specific skills is often discouraged by physical therapists and other healthcare providers based on the potential benefits of performing these activities. For example, early locomotion skills such as crawling allow the child the ability to explore his/her environment. The child's ability to explore the environment is considered essential for general motor skill development[3]. Crawling also provides significant experience with eye-hand coordination, vestibular input, balance, body-spatial awareness, tactile input, kinesthetic awareness, and social maturation[3]. Experience and exposure to these various stimuli promote the development of more advanced motor skills. Research by Farber in 1982 suggests that, theoretically, children that do not go through the crawling phase will lack experience with heavy tactile, proprioceptive, and kinesthetic input that is associated with the quadruped weight bearing position which may be important to later upper extremity functioning[3]. Therefore, it has been traditionally accepted that it is clinically important for noncrawlers to develop body schema, motor planning abilities, and proprioceptive functioning through the stimulation of touch, gravity, and movement receptors[3]. A study by McEwan and colleagues examined the influences of early crawling experience on later motor skill development by comparing motor skills of children between the ages of 2 years 9 months and 5 years 8 months to age and gender matched peers identified as crawlers versus noncrawlers in

infancy. This study found noncrawlers to demonstrate a lower average motor performance and a decreased frequency of postures that required crossing of the midline[3].

While some research has shown skipping the development of motor skills to not be favorable, there is limited research regarding the relationship and potential implications of age appropriate attainment of early fine and gross motor milestones on the development of later motor skills. One study found that early development of body control skills such as head control and sitting were correlated with good gross motor skills at 3.5 years of age, but did not find a relationship of early hand control skills including reaching and manipulation with later fine motor development[4].

Therefore, the primary purpose of this research study is to discover the possible implications of early gross motor skills such as rolling, crawling, creeping, and scooting on the later fine and gross motor development of four and five year olds. The researchers hypothesized that children attaining these early milestones by the expected age of acquisition would demonstrate age appropriate fine and gross motor skills at ages four and five as tested with the Peabody Developmental Motor Scale- 2nd Edition (PDMS-2). In comparison, children who achieved these milestones later than the expected age of acquisition would demonstrate fine and gross motor skills below age appropriate levels at ages four and five according to the PDMS-2.

Methods

Population

Participants for this study were recruited from the four and five year old classrooms at San Angelo Early Childhood Center (SAECC). This facility was local to the two researchers conducting the study and their advisor. Furthermore, the research advisor was a member of the Board of Directors of the SAECC, so any concerns or questions could be easily addressed. Inclusion criteria for the study were as follows:

1) Participant must be between 48 and 71 months of age

2) Participant's parent or guardian must consent to the child's participation in the study

3) Parent/guardian must complete the retrospective questionnaire in its entirety

4) Child must be physically capable of participating in the PDMS-2 testing.

The twenty-seven (27) children participating in the study had an average age of 55 months (range 48 to 62 months). The participants started daycare at approximately 11.6 months of age (range 6 weeks to 36 months). During the week, the participants averaged about 7.5 hours watching television (range 1 to 38.5 hours) and about 8.5 hours playing outdoors outside of daycare (range 1 to 30 hours). Furthermore, 74% of our population has a yearly family income of $30,000 or less.

Instruments

The PDMS-2 is a comprehensive gross motor and fine motor assessment scale for development of children from birth to six years of age. It is based on a large normative sample of 2,003 participants. A total of 127 gross motor items and 122 fine motor items are included divided into six subsets - Reflexes, Stationary, Locomotion, Object Manipulation, Grasping, and

Visual-Motor Integration. However, only applicable tasks were elicited from the children based on chronological age and skill level as specified by the administration protocol of the PDMS-2. For example, the Reflexes subset contained items that are generally integrated by 12 months so it was not applicable to our study. The Stationary subset contained items such as timed standing on one foot, standing on tiptoes, sit ups, or push-ups to measure a child's ability to sustain control of his or her body within its center of gravity. Walking forward and backward, negotiating steps, running, galloping, skipping, and jumping were included in the Locomotion subset to measure a child's ability to move from one place to another. The final gross motor subset, Object Manipulation, observed catching, throwing, and kicking activities. The two fine motor portions are titled Grasping and Visual-Motor Integration. They measure a child's ability to use his or her hands grasping a marker or manipulating buttons, and their visual perceptual skills to perform hand-eye coordination tasks like cutting, building with blocks, and folding paper[5]. The fine and gross motor sections are scored separately to allow for comparison of developmental differences. The scores of the fine and gross motor sections are also combined to examine overall motor development. The motor skills included in PDMS-2 reflect everyday activities which minimizes the risk for the child with performance of this standardized test. The PDMS-2 was selected for this study because its primary application is to document developmental delay. In addition, the PDMS-2 is a widely used developmental test in pediatric research and clinical practice. The PDMS-2 has an inter-rater reliability of 0.96 and a test-retest reliability of 0.89-0.96, and an internal consistency of 0.97[6]. The researchers were trained by a practicing pediatric physical therapist on the administration of the PDMS-2 on children with and without developmental

delays prior to initiation of data collection. Both researchers were also able to administer several PDMS-2 tests under the supervision of the practicing therapist.

Procedure

A description of the purpose and process of the research study along with a consent form were distributed to the parents and/or guardians of 36 four and five year old children who attended the SAECC. In addition, a retrospective questionnaire was distributed. The researchers developed the retrospective questionnaire for the parents of the participants to complete to the best of their knowledge (Appendix A). The questionnaire included questions regarding general demographic information, participant health status, and the age of acquirement of motor skills including rolling stomach to back, rolling back to stomach, crawling, creeping, and scooting. Parents were to report the approximate age at which their children achieved these milestones based on time windows specific to each skill that correlates to early, average, late, or movement never achieved ranges based on current averages[7]. For the purpose of this study, crawling is defined as mobilizing using arms and legs *with* stomach touching the ground. Creeping is defined as mobilizing using arms and legs *without* stomach touching the ground. Parents and/or guardians who consented to their child's participation in the study signed and returned the consent form and questionnaire to the facility. A total of 31 consent forms and questionnaires were returned. During this process of receiving parent/guardian permission, the two researchers slowly integrated themselves into the classroom setting during play/free time periods to become familiar faces for any potential participants. As forms were returned, each child was assigned an identification number. These numbers were used on all documentation regarding the research study to ensure the confidentiality of data. After forms were returned,

the PDMS-2 was then administered to assess each participant's gross and fine motor skills. Of the 31 parent questionnaires (Appendix A) returned, twenty-seven of these were included in data analysis- two children withdrew attendance from the Early Childhood Center prior to being tested, one child was unable to be tested due to limited attendance, and one child was unwilling to complete testing after three attempts. The PDMS-2 assessments were completed over a span of nine weeks. The assessments were administered in the common area of the SAECC. The date of testing and results were recorded. One researcher conducted the gross motor portion of the PDMS-2, while the on-looking researcher recorded data and provided prompting when necessary. The roles of the researchers switched for the fine motor portion of the testing. These roles for the administration of fine and gross motor portions of the PDMS-2 remained consistent throughout the entirety of testing to increase reliability.

Statistical Analysis

Data analysis was conducted with SPSS for Windows recording mean, standard deviation, Levene Statistic, ANOVA, and a post hoc Tukey HSD when applicable. Levene Statistic was used to test for homogeneity of variances as a prerequisite to perform an ANOVA. A one-way analysis of variance (ANOVA) was used in this research study to compare the possible implications of early, average, and late achievement of developmental motor skills – rolling stomach to back, rolling back to stomach, crawling, creeping, and scooting - on the later fine and gross motor development of four and five year olds. ANOVAs were performed to compare the [early, average, and late] achievement of each individual developmental motor skill and their respective fine and gross motor skill performance on the PDMS-2. A Post Hoc assessment, the Tukey HSD, was performed when the respective ANOVA analysis identified statistically significant findings.

Results

No statistically significant differences were found when comparing early gross motor skill achievement – rolling stomach to back, rolling back to stomach, crawling, creeping, and scooting - and later PDMS-2 *gross* motor quotients. Similarly, no statistically significant differences were found comparing rolling stomach to back, rolling back to stomach, crawling, and scooting achievement and later *fine* motor quotients. However, when comparing the achievement of creeping and later fine motor quotients, the ANOVA identified a p value of .007 (Table 1). This is deemed statistically significant due to the utilization of an alpha level $\alpha = .05$. A Post Hoc Tukey HSD was performed due to the findings of a statistically significant value, to further analyze multiple comparisons between groups. This post hoc test found that between groups of average attainment and late attainment, the findings were significant p=.034. This was also true when comparing early attainment and average attainment, p =.013. When comparing early attainment to late attainment, the post hoc assessment revealed a p value of .737 which is not statistically significant.

Despite only one of our comparisons being statistically significant, there were multiple between groups comparisons displaying a negative correlation between early motor skill achievement and motor quotients (Table 2). Correlations of the milestone achievement and gross and fine motor quotients are depicted in Figure 1-A & B, respectively. Attainment of rolling back to stomach, crawling, creeping, and scooting showed a negative correlation with gross motor skills at ages 4 and 5. Early achievement of these early motor milestones was associated with more advanced gross motor skill performance. Not attaining these skills was associated with lower level gross motor skills. Similarly, achievement of crawling, creeping, and

scooting demonstrated a negative correlation with later fine motor skills. Delayed attainment or not achieving these early motor milestones was associated with lower level fine motor skills at ages 4 and 5. Age of attainment of creeping demonstrated the strongest correlation with gross and fine motor performance in this study.

Discussion

Although statistical analysis did not reveal significant differences between groups of early, average, and late attainment of early milestones such as rolling, crawling, creeping, and scooting compared to later motor skills, our study did demonstrate expected negative correlation between the variables for most skills. The negative correlations supporting the researchers' proposal that children attaining early gross motor skills by the expected age of acquisition would demonstrate age appropriate fine and gross motor skills at ages four and five as tested with the PDMS-2. This is similar to previous research in that values were not deemed statistically significant between groups; however, these studies also displayed correlations between early motor milestones and later skills [McEwan]. The importance of achieving early milestones generally occurring before the age of one is debated among healthcare professionals and research worldwide. Early developmental physical therapy specialists claim that during the first years of life infants achieve the foundational physical, cognitive, social, and self-help skills for future developmental progress, and these skills are attained according to a predictable order. Infants learn further skills through interaction with their environment and these specialists claim that can only come about with the ability to move freely[8]. For example, McEwan, Dihoff, and Brosvic state that crawling – defined as movement on hands and knees with stomach contact – involves a state of eye-hand coordination, vestibular processing,

improvement of balance and equilibrium, spatial awareness, tactile input, kinesthetic awareness and social maturation[3]. Similarly, researchers Gesell and McGraw – two foundational researchers on motor development – claim crawling on hands and knees to be precursory to walking. However, they also contingently state that the prone and/or sitting positions *are not* mandatory for appropriate development[9]. And still others postulate that crawling is a more recent invention and is not necessary as a precursor to walking. A cross-cultural study by Adolph, Karasik, and Tamis-LeMonda found that up to 17% of British infants skip crawling, 29% of Jamaicans skip crawling and the remaining infants began crawling at the same age as they began walking – 10.1 months and 10 months for crawling and walking, and many African infants do not crawl due to concerns of poor sanitation and infection[1]. It is reported that 40% of American infants from the early 20th century skipped crawling. Researchers theorize that this was perhaps to avoid catching their knees and feet at the edge of their long gowns[1]. This current study sought insight into this debated topic and examined the relationship between attainment of early motor milestones and the development of fine and gross motor skills in children ages 4 to 5.

A study by Hinkley and colleagues found that there are many factors that can contribute to a child's motor development. Demographic, biological, psychological, cognitive, emotional, behavioral, social, cultural, and physical environmental variables were potential correlates considered for association with physical activity in preschoolers. Television use/sedentary behavior was the most frequently addressed behavioral factor correlated to physical activity. Three studies between the years 1980 and March 2007 found that there was a negative correlation between TV viewing and physical activity in preschoolers, while three opposing

studies found no correlation [10]. The questionnaire utilized in this current study addressed approximate minutes of TV viewing and outdoor play not including daycare hours. Parents were also asked to report the age at which the child started participating in daycare and the hours each week spent at the facility. A study by Vanderloo and colleagues aimed to assess whether the childcare environment represents an appropriate avenue to support physical activity among preschoolers. Among 13 publicly-funded childcare centers in London, Ontario they found low levels of moderate-to-vigorous physical activity (MVPA) and total physical activity (TPA) were accumulated among preschoolers with an estimated rate of 1.54 min/h spent in MVPA while at the childcare facility[11]. A similar study by Temple and colleagues' reported a comparable finding of 1.76 min/h[12]. These findings suggest that children attending daycare may not have the opportunity to participate in 180 minutes of daily physical activity recommended by the Canadian Physical Activity Guidelines for the Early Years[13]. Another factor accounted for in the parent questionnaire for the current study is parent socioeconomic status. 713 child-parent pairs from San Diego and King County were recruited to observe the possible correlation between parent socioeconomic status (SES) and sedentary behaviors in children. This study found that there were no SES differences in children's overall or home –based MVPA or sedentary time, despite the lower SES group demonstrating greater access to electronic media devices in their bedrooms, lower access to portable play equipment, and more restrictive rules around outdoor play[14]. Similarly, a study from Ferreira and colleagues found that various estimates of family SES were generally unrelated to children's physical activity[15]. Likewise, our sample population was collectively of a lower income level, noted by their reported average yearly income. 74% of our sample population has a yearly family income of $30,000 or less.

There were some limitations to this current study. To begin with, a limitation to this study was the retrospective quality of the parent questionnaire (Appendix A). The questionnaire asked parents to report the approximate time for motor milestone achievement based on norms for early, average, and late ranges. All of these milestones occur before or at year one for the normally developing infant. The questionnaire was distributed to the parents or guardians of children between 48 and 71 months of age. Therefore, the accuracy of recall of specific time frames for the development of a child's motor skills may be decreased as opposed to retaining this data closer to the time of attainment. An additional limitation of this study was the small sample size (n=27). The small sample size resulted in only one to two children in the early and late achievement groups for certain skills. The small subsamples result in the possibility of skewed data based on the performance of these specific children. For example, only one child was late in achieving rolling stomach to back. This child performed fine motor skills well above the age expected skill level. This may or may not be typical for performance if a larger group of children with late attainment of this skill were included. Therefore, the ability of the results of this study to be generalized to a larger population is decreased.

Future research should incorporate the use of a larger sample size, a longitudinal study design in order to obtain questionnaire information during the infant age while early motor milestones are being achieved, and a more accurate control for other factors contributing to motor development in order to develop a better understanding of the correlation between early motor skill achievement and later motor development.

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Table 1. Comparison of early motor skills and PDMS – 2 results

Early Motor Skills	P Value
	Gross Motor Scales
Rolling Stomach to Back	.540
Rolling Back to Stomach	.884
Crawling	.562
Creeping	.227
Scooting	.930
	Fine Motor Scales
Rolling Stomach to Back	.627
Rolling Back to Stomach	.344
Crawling	.243
Creeping	**.007**
Scooting	.427

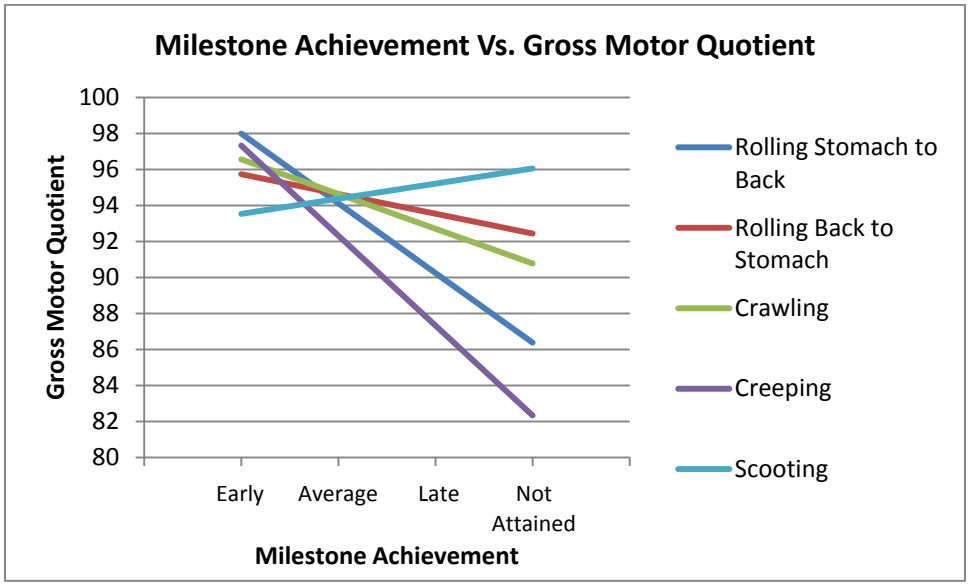
The bolded value is statistically significant.

Table 2. Correlation Coefficient

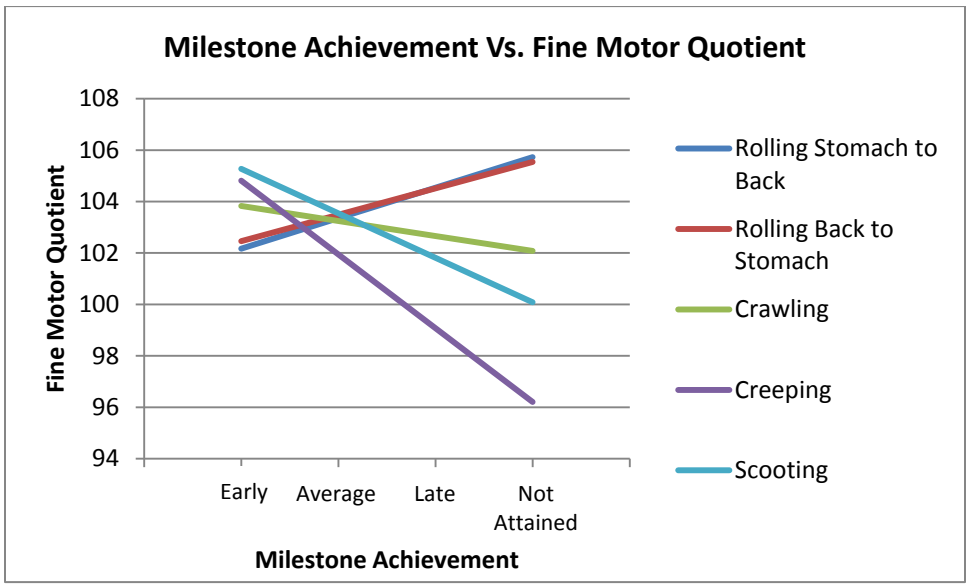
Early Motor Skills	Correlation Coefficient
	Gross Motor Scales
Rolling Stomach to Back	**-3.88**
Rolling Back to Stomach	**-1.10**
Crawling	**-1.93**
Creeping	**-5.00**
Scooting	0.84
	Fine Motor Scales
Rolling Stomach to Back	1.19
Rolling Back to Stomach	1.03
Crawling	**-0.58**
Creeping	**-2.87**
Scooting	**-1.73**

The bolded values have negative correlation coefficients.

Figure 1: Correlation of Milestone Achievement and Gross and Fine Motor Quotient.



A) Attainment of early motor milestones at or before expected developmental norms showed a negative correlation with gross motor skills at ages 4 and 5 for rolling back to stomach, crawling, creeping, and scooting. Early achievement of early motor milestones was associated with more advanced gross motor skill performance, while not attaining these skills was associated with lower level gross motor skills.



B) Age of achievement of crawling, creeping, and scooting demonstrated a negative correlation with fine motor skills. Early attainment of these skills was associated with higher level fine motor skill performance. Delayed attainment or not achieving these early motor milestones was associated with lower level fine motor skills at age 4 and 5.

Appendices

Appendix A: Parent Questionnaire

Parent/Guardian Questionnaire

Child's confidentiality code [to be filled in by researchers]: _____

Gender: _____ Date of Birth: _____ Race/Ethnicity: _____
List any known medical conditions: _____
_____

Please answer the following questions to the best of your ability:

How long was the pregnancy? Full term □ Pre term □
If pre term, how early? _____

Were there any difficulties with the pregnancy? yes□ no□
If yes, please explain: _____
_____

From the ages of 0-6 months, my child slept mostly on their: back □ stomach □

From the ages of 6 months-1 year, my child slept mostly on their: back □ stomach□

Daycare
At what age did your child start participating in daycare? _____
How many days per week/hours per day did your child attend?_____

Does your child participate in any sports or extracurricular activities? yes□ no□
If yes, please list sports with number of hours of participation per week:
_____
_____

Does your child eat fruits and vegetables daily? yes □ no □
If yes, about how many combined servings of fruits and vegetables per day?
[According to the USDA, 1 serving = ½ cup]
1 □ 2□ 3□ 4□ 5□ 6□

Average yearly income of parent(s):
< $15,000□ $15,000-$30,000□ $30,000-$45,000□ $45,000-$60,000□ >$60,000□

About how many minutes per week does your child watch television?
_____

About how many minutes per week does your child spend outdoors (not including daycare hours)? _____

Activities of Interest:

Please complete the following to the best of your knowledge.

1. Rolling: Rolls from stomach to back.
    a. Did this occur in your child? yes□ no□
    b. If so, choose age range when skill was first observed.

    □ <4 months □ 4-6 months □ >6 months

2. Rolling: Rolls from back to stomach.
    a. Did this occur in your child? yes□ no□
    b. If so, choose age range when skill was first observed.

    □ <5 months □ 5-7 months □ >7 months

3. Crawling: Mobilizes using arms and legs **with** stomach touching the ground
    a. Did this occur in your child? yes□ no□
    b. If so, choose age range when skill was first observed.

    □ <5 months □ 5-9 months □ >9 months

4. Creeping: Mobilizes using arms and legs **without** stomach touching the ground
    a. Did this occur in your child? yes□ no□
    b. If so, choose age range when skill was first observed.

    □ <9 months □ 9-11months □ >11 months

5. Scooting: Mobilizes in seated position using arms and only one leg
    a. Did this occur in your child? yes□ no□
    b. If so, choose age range when skill was first observed.

    □ <8 months □ 8-10 months □ >10 months

Pictures provided by: http://www.dinf.ne.jp/doc/english/global/david/dwe002/dwe00237.html[16]